Experiments to Assess the Impacts of Technology Transitions from Copper to Optical Fiber and from Analog Voice to VoIP in the Fixed Access Network

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This is a proposal to conduct experiments, with the Commission's oversight and participation of public network providers and customers, to evaluate the potential impact on enduring Network Values - public safety, universal service, competition, and consumer protection - due to technology transitions in the public fixed access network from copper-based analog telephone Customer Premises Equipment (CPE) with centralized electrical powering to: 1) fiber-based analog telephone service with centralized optical powering, 2) fiber-based digital VoIP telephone with local electrical powering, 3) fiber-based VoIP telephone with centralized optical powering. The experiment will also investigate the upgrade of the voice CPE to multimedia CPE to exploit the more than 30,000 GHz bandwidth of optical fiber over 10 km range.

Statement of Purpose and Proposed Metrics

The objective of this proposal is to assess the impact on the enduring Network Values due to technology transitions in:

1. physical layer of the public fixed access network from all-copper based to a Fiber-To-The-Cabinet/Node (FTTC/N & HFC) based network
2. physical layer from all-copper based to an all fiber-based Fiber-To-The-Home/Premises (FTTH/P) with centralized optical powering
3. the CPE network and service layers from anlaog voice to digital VoIP
4. the CPE powering from centralized electrical or optical powering to local, distributed, or reverse powering that might need battery back-up at Customer Premises (CP), and
5. analog telephone CPE to digital multimedia integrated CPE supporting voice, text and video, which might need a centralized powering for essential services, such as emergency services, and local, distributed, or reverse powering for non-essential services that might need battery back-up.

Figure 1 shows the telecom fixed access network connecting the CPE to the CO. The CO houses a primary battery, secondary back-up battery, and a stand-by generator with fuel storage for powering the telephone CPE and CO equipment. The figure can be used to identify all technology transitions from legacy to next generation access network.

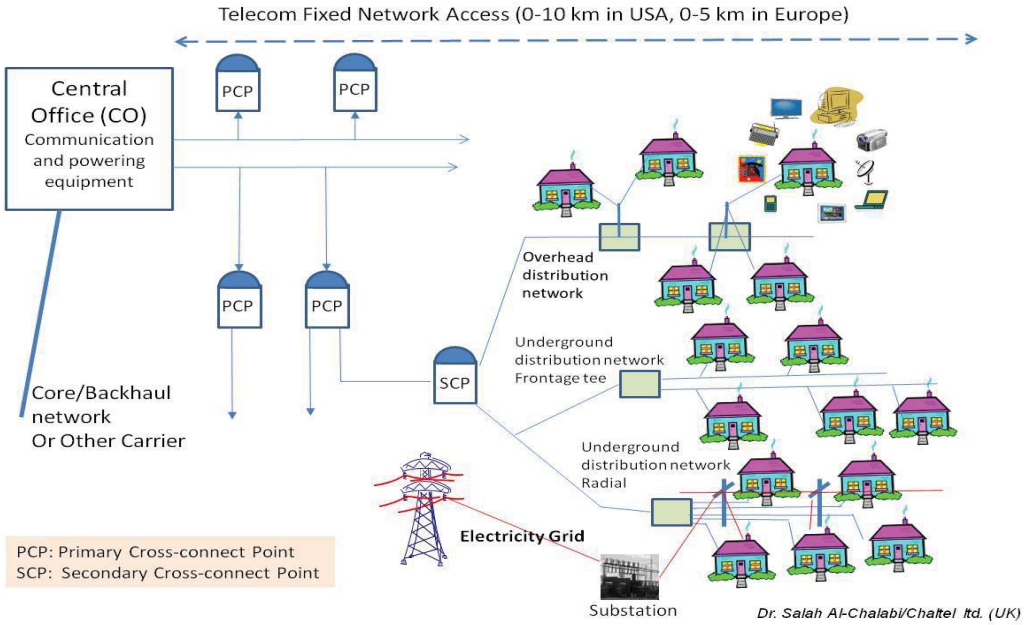

Figure 1: Telecom Public Fixed Access Network and Local Electricity Grid

The figure also shows the distribution part of the electricity grid. Table 1 lists the different standard CPE and access network equipment powering architectures. The current copper-based an`alog telephone uses centralized, while local powering is used in current VoIP digital telephone over FTTH/P or cable modem, and reverse powering is being standardized the G.fast (post VDSL) standard to power FTTC/N to deliver 1 Gbps over the last 100 m of copper.

Powering	Definition and main power source location	Back-up battery location	Resilience/ Restoration time	Cost	Physical Layer Technology & Architecture
local powering:	powering a telecommunications equipment by a (dedicated) power unit implemented at the CP.	CP (indoor or outdoor)	low/long	high	FTTH, Wireless (Wi-Fi, cellular, Wi-Max, Satellite set-top box, TV), CATV, VoIP (modem or Personal Computer)
reverse powering:	power from the CP is provided to a Distribution Point (DP) outside the CP by means of a dedicated power copper line from each CP. The DP can serve one or several CPs.	DP or CP	Low/long	high	FTTC/B (evolving G.fast standard)
cluster powering:	remote powering of a cluster of equipment, in which the power source is located outside a telecommunications centre (CO).	Outdoors in - street cabinets or - underground manholes	medium/ medium	medium	FTTB, FTTC/N , CATV, wireless (base stations, satellite ground stations)
centralized powering:	remote powering in which the remote power source is located in a telecommunications centre (CO).	CO (a back-up generator can also be used with stored fuel)	very high/ short	low	Copper, FTTH (remote optical powering)

CP: Customer Premises

CPE: Customer Premises Equipment

CO: Central Office

DP: Distribution Point

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Table 1: Standard Access Network Powering Architecture

The baseline of the proposed metrics will be those currently used to characterize legacy analog telephone service delivered over copper with centralized powering. Those include:

1. Quality of voice service under normal operating condition: speech quality, interference
2. Availability of voice service: Mean-Time-Between-Failures (MTBF), time duration of a failure..etc.
3. Restoration time of service during a simulated natural and manmade disasters
4. Ability to access 911/E911 during a power outage, and duration of accessibility
5. Access to telephone service, and special devices to enable access for people with special needs to services already supported by legacy copper-based network
6. Possibility to deliver multimedia 9-1-1 "calls", including IP-based systems, to 911 call centers that could receive text, pictures and videos from members of the public.
7. Impact on the Nation's critical communications infrastructure
8. Maintaining other services that are currently supported by copper-based legacy system; such as fax machines, burglar alarms, medical monitoring devices, credit card readers,
9. Possibility to upgrade the communication system to deliver symmetrical broadband and services exploiting the more than 30,000 GHz of optical fiber over a distance of 10 km.
10. Safety of network personnel and customer due to high optical powering levels

Scope

The arenas in which the experiments can be conducted cover:

1. population densities: urban, suburban and rural areas
2. geographical areas: plain, hills, mountains, flooding, earthquake, volcano …
3. climates: cold, hot moderate, humid, dry

The experiments can also cover areas where the status of network deployment is different;

1 green-field deployment, where no other fixed network is already deployed
2 brown-field deployment, where a legacy network already exists, but needs to be upgraded or replaced
3 non-competitive markets where there is only one network operator

Technical Parameters and Timeline

Examples of all transitions, except FTTH with centralized optical powering, have already happened in the marketplace. This makes it relatively easy to assess the impact of technology transition from legacy copper-based system to FTTN/C with the different powering architectures, or the transition to FTTH/P with local powering by evaluating the impact of those commercially available services delivered over different network technology. Initial market research has already indicated that currently deployed CPE of optical communication systems based on GPON (ITU standard) and EPON (IEEE standard) consume more than 2 W in the idle state and considerably more in the idle/quiescent state and they must rely on local powering with back-up battery to support any service. Similarly, VoIP telephone, modems and Anolog Telephone Adapters (ATA) consume more than 1 W in idele state, compared to 1 mW consumed by a telephone apparatus in the idle state. The impact of those technology transitions on the network values can be objectively assessed by the FCC, with the participation of the network and service providers, over a period of 6-12 months.

Figure 2 shows the technology transition from the legacy copper-based analog telephone with centralized electrical powering to a fiber-based analog telephone with centralized optical powering. To conduct an experiment to assess the impact of this transition on the enduring network values, low power consumption optical communication system (less than 1 mW in the idle/quiescent state) with centralized optical powering is required. The technical design of the system is completed, and a system can be built and tested within 12 months.

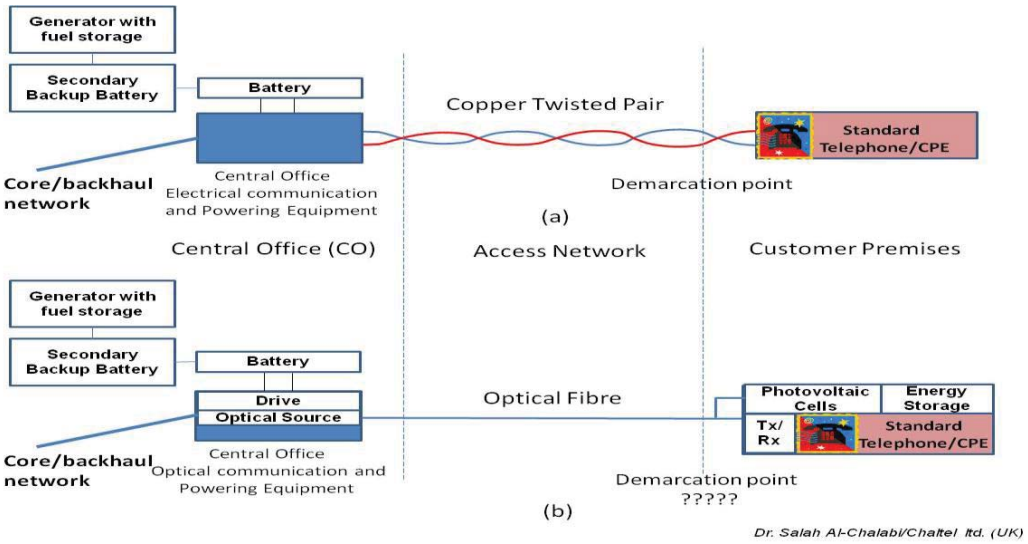

Figure 2: Technology Transition from Copper-based Network with Centralized Electrical Powering to Optical Fiber-based Network with Centralized Optical Powering

The other proposed technology transitions, shown in figure 3, is in the CPE from copper-based analog telephone with centralized powering over copper twisted pair, figure 3a, to fiber-based analog telephone with centralized optical powering over single mode optical fiber, figure 3b, and to fiber based digital VoIP telephone with centralized powering over single mode optical fiber, figure 3c.

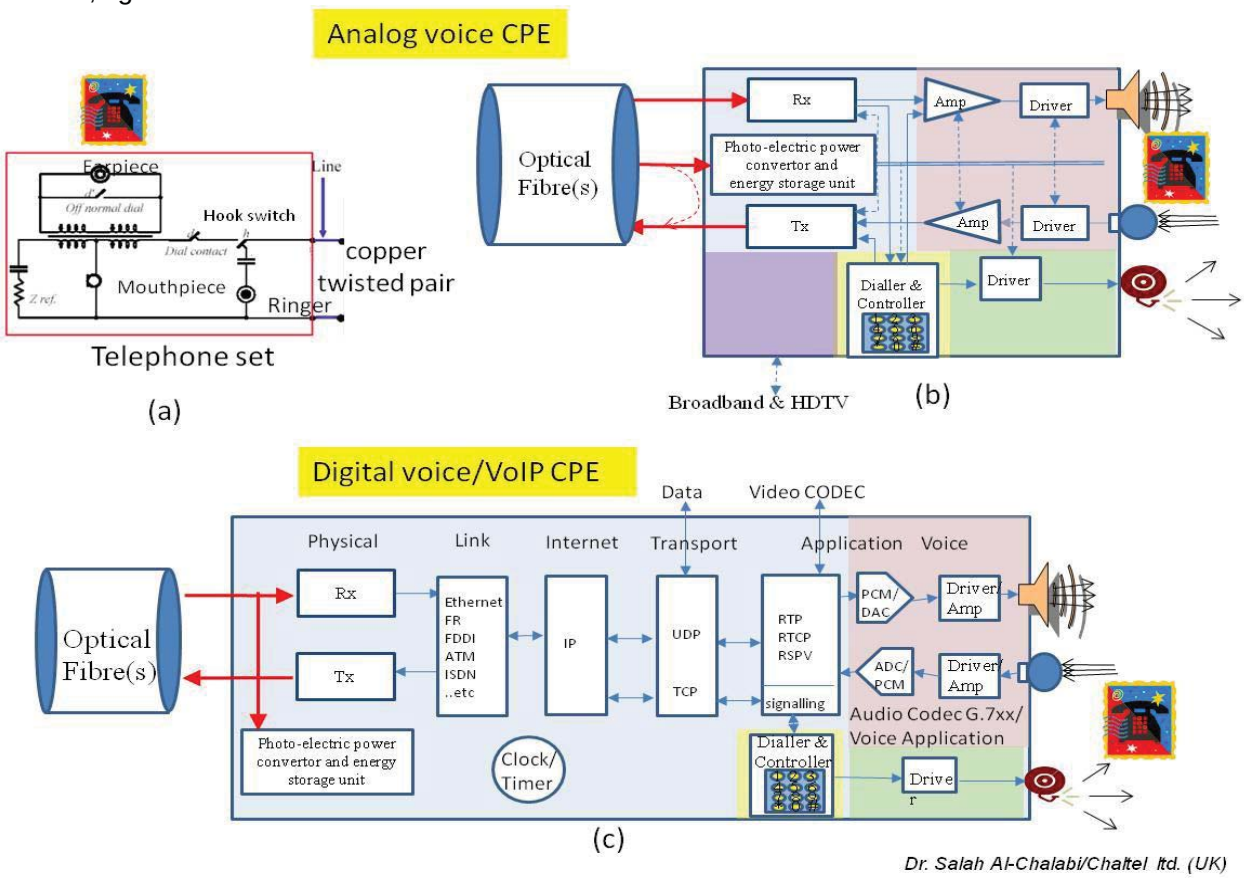

Figure 3: Different implementation of telephone CPE (a) copper-based analog telephone with centralized powering (b) fiber-based analog telephone with centralized optical powering (c) fiber-based digital VoIP telephone with centralized optical powering

Customer Participation

In principle, the experiments can be conducted without requiring existing customers to participate in the experiment. The performance of existing systems can be objectively compared.

Regulatory Relief or Authorizations

The experiments will not involve removing or reducing or impairing a legacy service, as the experiments will be conducted on existing customer connections already offered in the marketplace.

Other Governmental Entities

The proposed experiments will comply with all applicable State laws and regulations and existing technical standards, as the services and networks are already offered by several network and service providers in different States.

VALUES-BASED CONDITIONS, PRESUMPTIONS AND QUESTIONS

The experiments will satisfy the conditions and presumptions listed in the FCC's order:

A. Public Safety

1. Conditions

911/E911 and Next Generation 911 Capabilities

The experiments will examine whether centralized powering architecture, which became the standard for powering the telephone over copper based physical layer, offers the highest network resilience and service availability at lowest cost and shortest restoration time to ensure uninterrupted access to emergency services through 911/E911 in case of power outage.

Centralized optical powering architecture sends optical power from the CO to the CPE over the fiber to power the telephone. Although the optical power is limited by the power handling capacity of the optical fiber, enough optical power can be delivered to operate the anlog telephone to maintain reliable access to emergency services through 911 and support E911 service. The powering equipment at the central office consists of primary battery, secondary back-up battery, and a standby generator with fuel to ensure service availability of better than 99.999% (five nines).

Other CPEs; such as broadband modem, HDTV set-top box, cordless telephone base, VoIP modem…etc, consume more power and are locally powered. Text, image, video and other features can be added to voice to support the emerging NG911 architecture, but video equipment consumes more power than can be delivered over optical fiber and will be powered locally.

The impact of the transition to all-IP at the CPE on power consumption and enduring network values will be examined and assessed.

Safeguards to Ensure Public Safety Functionality in Adverse Conditions

In the event of public safety failure, the immediate restoration of legacy service, which is used as the baseline technology, will be possible.

Protect Essential Communications Services for Safety of Life and National Security

The technical transitions that are made to currently approved and deployed systems are immediately reversible if any deterioration in service occurs. This should ensure that essential national security and federal safety of life communications services are protected.

Network Security

The proposed experiments will compare the security of a point-to-point access network to a shared access network with point-to-multipoint or multipoint-to-multipoint physical layer architecture. The security at the network level will be same as for currently deployed networks.

Backup Power

One of the main objectives of the experiments is to assess the impact of technology transitions from the current anlog voice service over copper with centralized powering in the physical or network layers. The experiment will comply with backup power rules adopted in the *911 Network Reliability R&O*. The experiment will evaluate impact of providing power backup for both facilities within the operator's network and for end-user equipment located at customer premises. The service quality and availability will be evaluated for a range of use cases involving commercial power outages of varying duration, i.e. ranging from a few hours to several days or weeks. The experiment will compare the services parameters for different technology transition scenarios including: copper-based network with centralized electrical powering, fiber based connection with optical centralized optical powering, VoIP customer

premises equipment with local powering, and VoIP service over FTTC/N or HFC with distributed powering.

Outage Reporting
Outage reports and PSAP notification will be filed complying with Part 4 rules that pertain to each legacy service being replaced during the experiment, regardless of the extent to which the rules would apply in the first instance to the type of IP-based service that replaces it.

CALEA Capabilities
The experiment will comply with the Communications Assistance for Law Enforcement Act (CALEA).

2. Presumptions

Network Reliability
The reliability of the proposed low power consumption optical communication system with centralized optical powering will be compared to current copper-based analog telephone with centralized electrical powering. This includes ability to function during commercial power failures and security from external attack. The best practice recommended by the Communications Security, Reliability, and Interoperability Council (CSRIC) will be applied during the experiment.

Provision of Public Alerts
The support of Wireless Emergency Alerts (WES) will be considered, but if this proves to be difficult to achieve within the experiment duration then application will be filed to rebut this presumption by providing notices of this non-election to affected customers and the Commission.

Public Safety Priority Services
The proposed experiment will have no impact on priority access, routing, provisioning, and restoration for essential national security and emergency preparedness communications. The experiment will not impact the Wireless Priority Service (WPS), Government Emergency Telecommunications Service (GET) and Telecommunications Service Priority (TSP).

B. Universal Access

The *USF/ICC Transformation Order (2011)* adopted the goals to: (1) preserve and advance universal availability of voice service; (2) ensure universal availability of modern networks capable of providing voice and broadband service to homes, businesses, and community anchor institutions; (3) ensure universal availability of modern networks capable of providing advanced mobile voice and broadband service; (4) ensure that rates for broadband services and rates for voice services are reasonably comparable in all regions of the nation; and (5) minimize the universal service contribution burden on consumers and businesses.

In addition, the Connect America Fund requires the provision of broadband with actual speeds of at least 4 Mbps downstream and 1 Mbps upstream, with latency suitable for real-time applications and services such as VoIP, and with monthly usage capacity reasonably comparable to that of residential terrestrial fixed broadband offerings in urban areas.

The proposed future-proof fiber-based (> 30,000 GHz bandwidth over 10 km) optical communications system is expected to satisfy, and surpass all these requirements.

Ensuring Access for Persons with Disabilities
The experiments will not jeopardize access to communications for persons with disabilities. The disability accessibility requirements mandated by statues and Commission rules will be met, but

if this proves difficult or impossible to achieve within the duration of the experiment then a waiver from these regulations will be filled with the Commission.

The experiment will consider and study the impact of the technology transition on the provision of TRS, the transmission of remote closed captions, and the development and use of, and compatibility with assistive technologies.

Specific Populations
The experiments will be designed to protect the interests of specific vulnerable populations, such as the elderly, individuals with limited English proficiency (LEP), low-income populations, residents of Tribal lands, and others who likely will be affected by changes in communications technology in ways different from the general population. This will be achieved by deploying innovative, low cost technologies that deliver Universal Voice Service, and future-proof network with extremely high bandwidth (more than 30,000 GHz), while preservintg the enduring network values.

Maintain Universal Service Status Quo
The experiments will not deviate from any existing universal service rules and policies.

Preserve and Enhance Broadband Access
The bandwidth of an optical fiber is more than 30,000 GHz. The transition from copper-based to optical fiber-based physical layer with centralized optical powering that delivers the Universal Voice telephony service will provide a future-proof physical infrastructure in urban, suburban, and rural areas. The new and innovative optical technology provides levels of Internet access better than any other technology. The new technology will offer levels of universal voice service similar to legacy copper-based telephone service.

C. Consumer Protection

Customer Privacy
Consumer privacy will not be impacted by the optical technology used in this experiment.

Truth in Billing, Slamming, Cramming
The experiment will comply with the truth-in-billing rules, which are intended to address both slamming and cramming, and the Commission's other anti-slamming rules.

Local Number Portability
Local Number Portability will not be impacted by the optical technology used in this experiment.

Routing
Routing will not be impacted by the optical technology used in this experiment.

CUSTOMER NOTICE FOR SERVICE-BASED EXPERIMENTS
Notice to Customers: Participating and affected customers will be contacted by post or emails informing them about the experiments, and how they can choose to participate in the experiment voluntarily. The customers will be notified that the experiment is being conducted with the Commission oversight, and that the Commission encourages customers to provide feedback in this docket, and to provide the customers with instructions for doing so.

Notice of Network Changes: The information sent to the customer will include any relevant network changes and its timing, what features of the existing technology will no longer be available on the new technology and how that may impact third-party devices and services the customer uses (e.g., medical monitoring services); how the services will change including any differences in how applicants will provide their customers adequate notice of and information about the experiments.

DATA COLLECTION AND REPORTING (Docket 13-5)
Progress reports will be submitted to the Commission every 3 months from official project starting date. A final report will be submitted at the end of the project.

The data collected from the experiments will help to understand how it relates to the enduring values embodied in the statute. To foster a robust public discussion about the impact of technology transitions that is fact-based and data-driven, the results of those experiments will be “open data” so that data are publicly available, or made available pursuant to protective order against non-disclosure as appropriate.

The data will include key attributes of services, including IP-based, such as network capacity, call quality, device interoperability, service to persons with disabilities, system availability, 911 and PSAP service, cybersecurity, call persistence, call functionality, and service coverage, impact of the transitions on people with disabilities and other specific populations, such as consumers living on Tribal lands. Consumers’ experiences during the experiment will be measured using a questionnaire. The experiments will include a “control group” already provided with copper-based analog telephone service with centralized powering, and an 4 Mbps downstream 1 Mbps upstream broadband connection. The control group will be within the same geographic area, such as a wire center, as the experimental group. Collected data in the experiment or non-experiment areas will be clearly indicated.

All data related to public safety, law enforcement, cybersecurity, and national security will be clearly marked. The data will clearly measure the transition’s impact on government functions (e.g., police, fire, Emergency Medical Services (EMS), or the Federal Aviation Administration (FAA) or Department of Defense (DoD), consumers’ ability to access 911 and other emergency services, other public safety and security requirements currently performed by traditional PSTN systems, including 911 calls; CALEA requirements; internally and externally caused network outages or disruptions to service; and ability to meet cybersecurity or other threats and disasters.

The data will be submitted in a manner that ensures protection of customer privacy consistent with applicable privacy laws and regulations. Information or records that are subject to laws or regulations related to customer proprietary network information (CPNI), will not be submitted. In addition, the applicability of other privacy protections, including the Electronic Communications Privacy Act as well as the prohibitions related to customer privacy described in 47 U.S.C. § 551.will be complied with.

The economic impact of the transition from copper based to fiber-based (more than 30,000 GHz bandwidth over more than 10 km range) physical layer offering access to all foreseeable Internet and HDTV services and the will be assessed.